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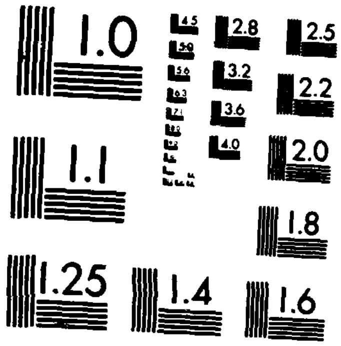

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NDRI-PR 86-09
AUGUST 1986

AD-A174 202

THERMAL PROFILE OF METALLIC BEADS IN A BEAD STERILIZER

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Research Progress Report NDRI-PR-86-09
Work Unit 63706N M0095003-3028
Naval Medical Research and Development Command
Naval Medical Command, National Capital Region
Bethesda, Maryland 20814-5044

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Thermal Profile of Metallic Beads in a Bead Sterilizer

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Introduction

The most common method of chairside dental bur sterilization is the immersion of the bur in a germicidal solution ~~such~~ as glutaraldehyde or chlorhexidine. This process is ~~very~~ time-consuming (~~over~~ 6 hours) and ~~can~~ result in corrosion damage to the bur. Further, residual debris on the instrument may prevent penetration of the solution, thereby compromising sterilization.[1] Steam autoclaving can also cause corrosion and dulling of instruments as well as being time-consuming.[2,3] Rapid application of dry heat appears to be the most efficacious and least damaging method for small instrument sterilization.[3,4]

Bead sterilizers are another commonly used chairside sterilization method, principally for endodontic instruments. The bead sterilizer consists of a heated chamber containing glass beads or, alternatively, salt. Its mode of sterilization is dry heat. Most manufacturers suggest that a sterilization time of 5 seconds is sufficient for sterilization.[5] The Council on Dental Therapeutics of the American Dental Association recommends a temperature of 218°C for 10 seconds for the sterilization of endodontic instruments.[6] However, several investigators have shown sterilization times ranging from 3 seconds to 14 minutes, are required, depending on conditions, but times of 10 to 20 seconds appear to be most common.[5,7,8,9]

A primary reason for the discrepancy in time of sterilization is a non-uniform temperature profile, particularly in the upper, central regions of the chamber.[5] Temperature profiles have been shown to vary as much as 60°C within the chamber.[8] Placement of the dental instrument into the cooler areas of the chamber requires a longer sterilization time and may result in incomplete sterilization. Other factors that influence sterilization are instrument size, material and level of precleaning. Larger, more massive instruments require longer sterilization times.[9] Dental burs have been shown to require more than 120 seconds sterilization time in an unmodified bead sterilizer.[10] Therefore, improvement of the temperature profile within a bead sterilizer will improve the efficiency and predictabilty of the sterilization process.

Purpose

The purpose of this study ~~was~~ to investigate the thermal profiles of different bead materials and combinations (layering) of bead materials in a standard bead sterilizer, and the potential effects of these profiles on dental bur sterilization.

Materials and Methods

The bead sterilizer used in this study was a PCA Model 2261 (Pulpdent Corporation of America, Brookline, MA 02147). Temperature measurements were made using a digital thermometer with a K-type thermocouple (Model HH-99K, Omega Engineering Inc., Stamford, CT 06907), calibrated according to the manufacturers recommendations. The thermocouple was fixed in a stabilizing apparatus to insure reproducibility of depth and position during temperature measurements. (figure 1) All test media were preheated for at least 30 minutes prior to conducting measurements. Media tested consisted of glass beads 1.69mm (provided with the sterilizer) and 3.10mm diameter (Arthur H Thomas Co., Philadelphia, PA 19105)as controls; stainless steel burnishing balls 1.60mm and 3.20mm diameter and aluminum burnishing balls 3.20mm diameter (Pioneer Steel Ball Company Inc., Unionville, CT 06085). Further, the combination of 1.69mm stainless steel with a 2.50mm thick cover layer of 1.69mm glass beads was tested to ascertain if the layer of glass provided a thermal insulating effect. Salt was also evaluated as a comparison. Pyrometer readings were taken at depths of 0.00mm (surface), 2.5mm, 5.0mm, 7.5mm, 10.0mm and 20mm. Each depth measurement was conducted at 2mm from the chamber wall, half way between the chamber wall and the chamber midline and at the midline. Isothermal profiles were extrapolated from the temperature measurements for each depth and position. An "insulating effect" was defined as the slope of the isothermal line for a two-layered material system more closely approaching zero than that of a single layer system of the same material.

The measurements of time to a specific temperature were made by painting the tip of the shank end of a friction grip bur (total length 22mm) with a temperature sensitive lacquer (Omega Engineering Inc.) rated at 218°C. Burs were then imbedded in the test medium to a depth of 12mm (cutting head down) and the time measured to the phase change of the lacquer.

Results

Under the conditions of this study , the following observations were made.

1. The temperature profile from the perifery of the chamber to the center was improved with metallic beads over that of glass beads and, to a lesser extent, over that of salt. (figure 2-8)

2. Considering the slopes of the isothermal lines, a slope of zero would be the ideal; that is, the temperature measured at any level would be the same at the center of the chamber as at the perimeter. In this case, the slopes of the isothermal lines (calculated from the high and low endpoints) for metallic beads and salt were 2-3 times less than those of glass beads. (Table 1)

3. The 215°C isothermal line for glass beads was around 10mm in depth at the center of the chamber. For the metallic beads and salt, the 215°C isothermal line ranged around 5mm in depth at the center of the chamber. Thus the requisite 218°C temperature line was available within a useful insertion length of the bur using the metallic beads. (figure 2-8)

4. The time measured to reach a specific temperature for the metallic beads was less than half that of the glass beads. The time measured to reach a specific temperature for salt was faster than that of the glass beads but not as fast as with the metallic beads. (Table 2)

(Cont fr p1)

Conclusions

The use of metallic beads in a standard bead sterilizer improved the temperature profile and the time measured to reach a specific temperature over that of glass beads. Salt, while an improvement over glass beads in most parameters, did not appear to provide a significantly more efficient system, particularly toward the center of the chamber. The data indicated that the bead sterilizer did provide an efficient, predictable means of chairside bur sterilization when suitably modified. Studies on the effect of the modified system on bur sterilization and damage are in progress.

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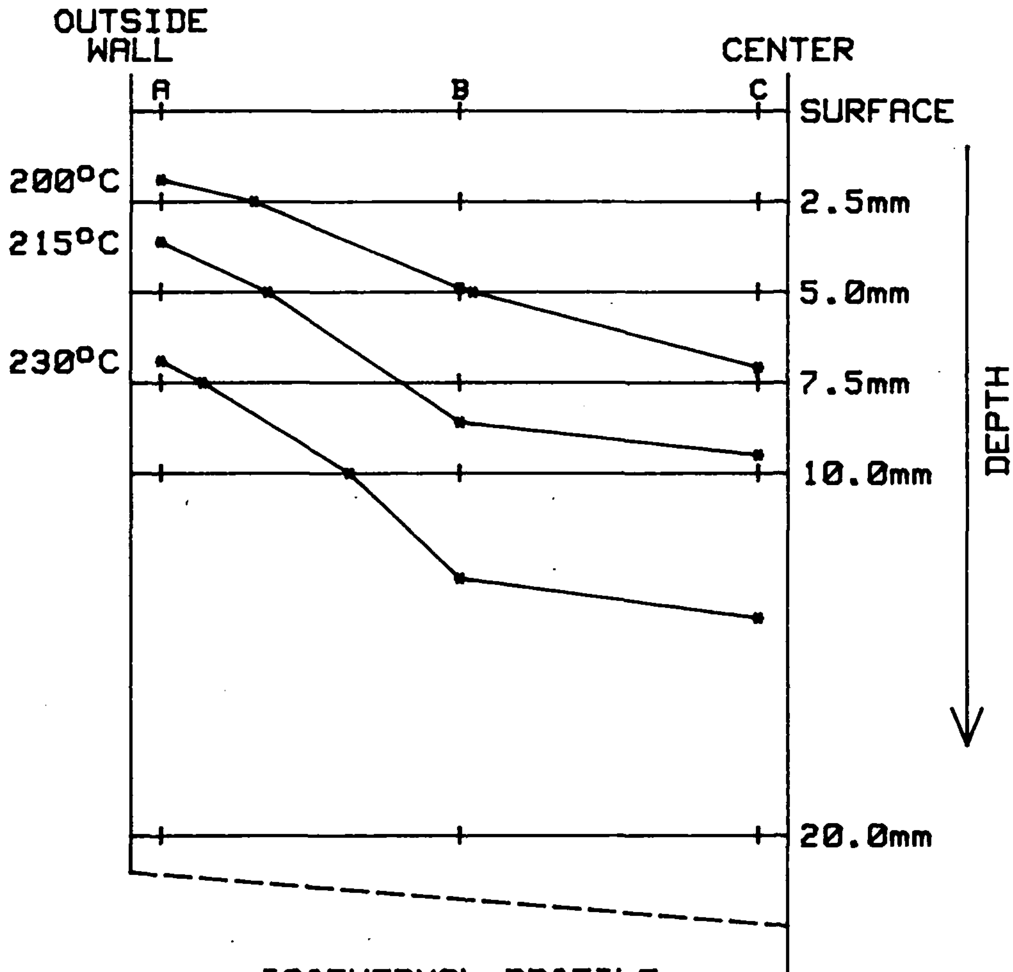
FIGURE 1

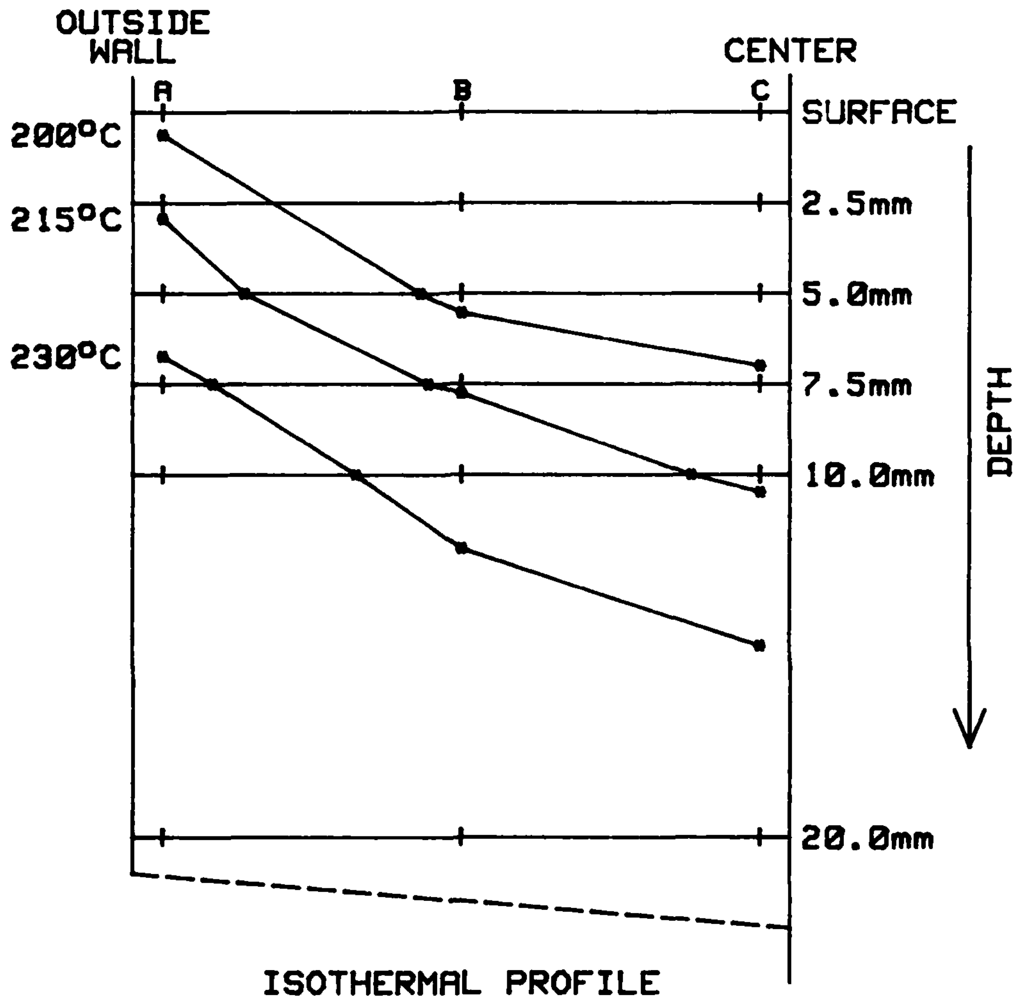
TESTING APPARATUS

FIGURE 2



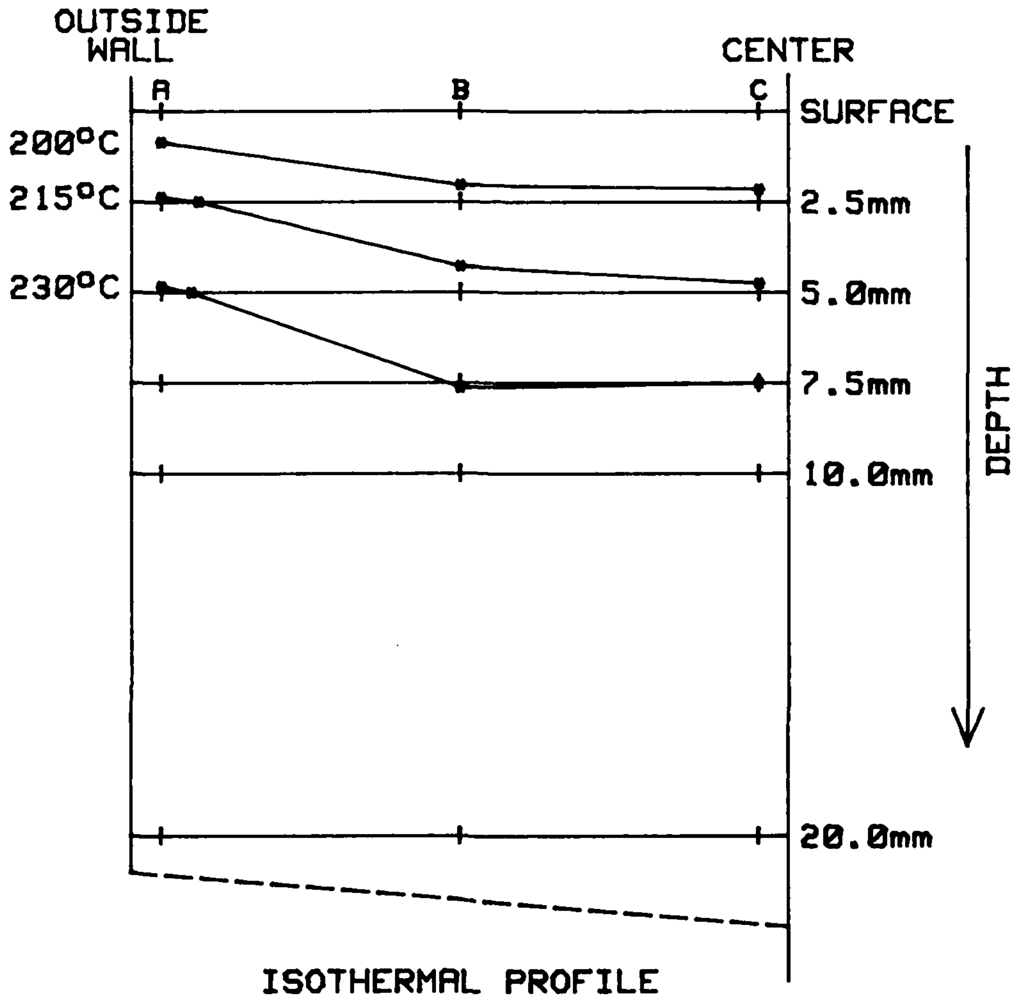
ISOTHERMAL PROFILE
TOP LAYER OF BEAD STERILIZER
NON-LAYERED SYSTEM
GLASS BEADS
.067 INCH (1.69mm) DIAMETER

FIGURE 3



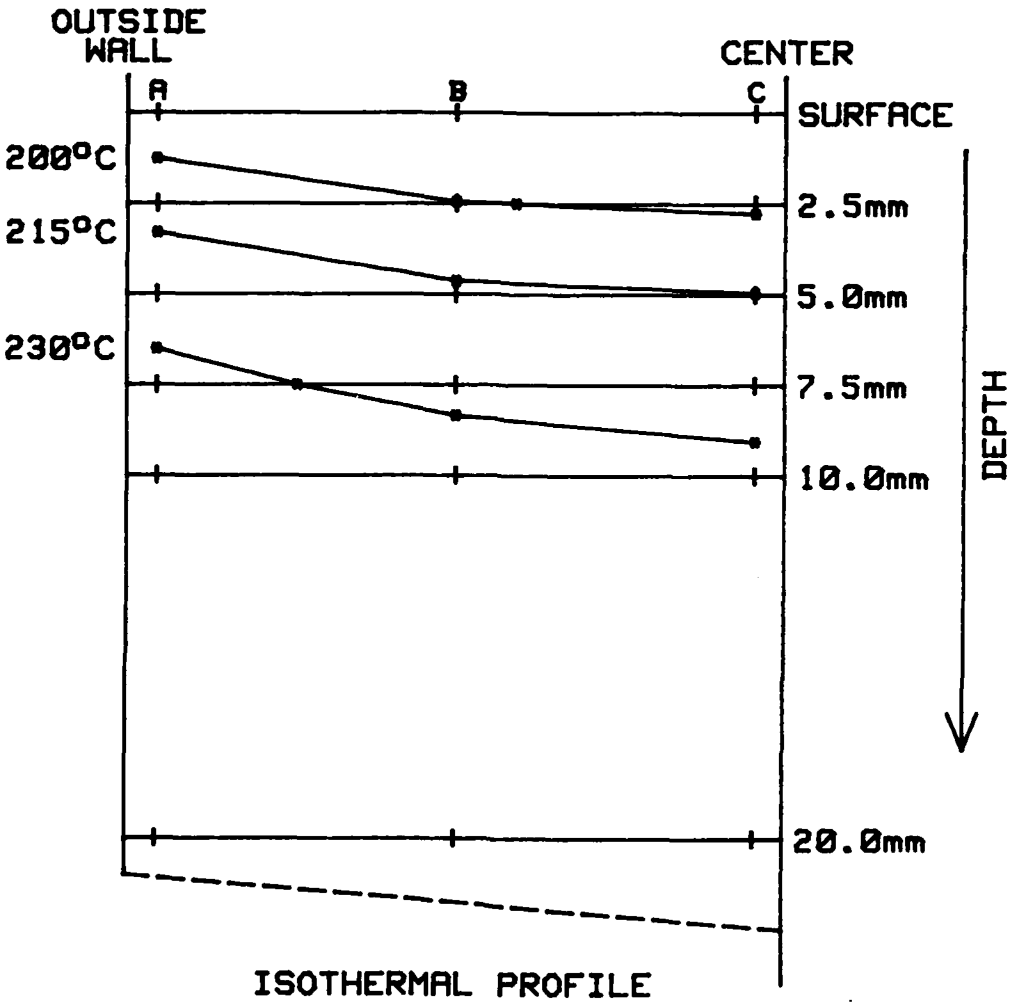
ISOTHERMAL PROFILE
TOP LAYER OF BEAD STERILIZER
NON-LAYERED SYSTEM
GLASS BEADS
.118 INCH (3.1mm) DIAMETER

FIGURE 4



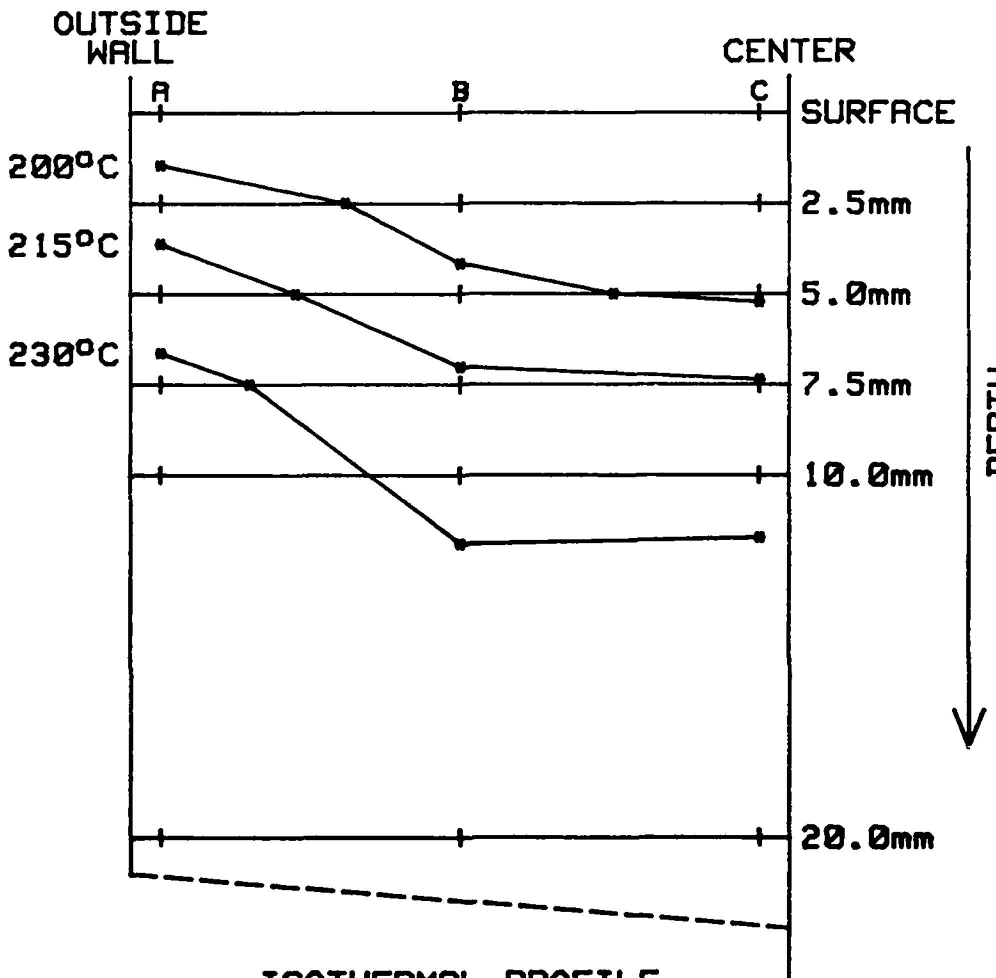
ISOTHERMAL PROFILE
TOP LAYER OF BEAD STERILIZER
NON-LAYERED SYSTEM
STAINLESS STEEL (TYPE 316L) BEADS
.062 INCH (1.6mm) DIAMETER

FIGURE 5



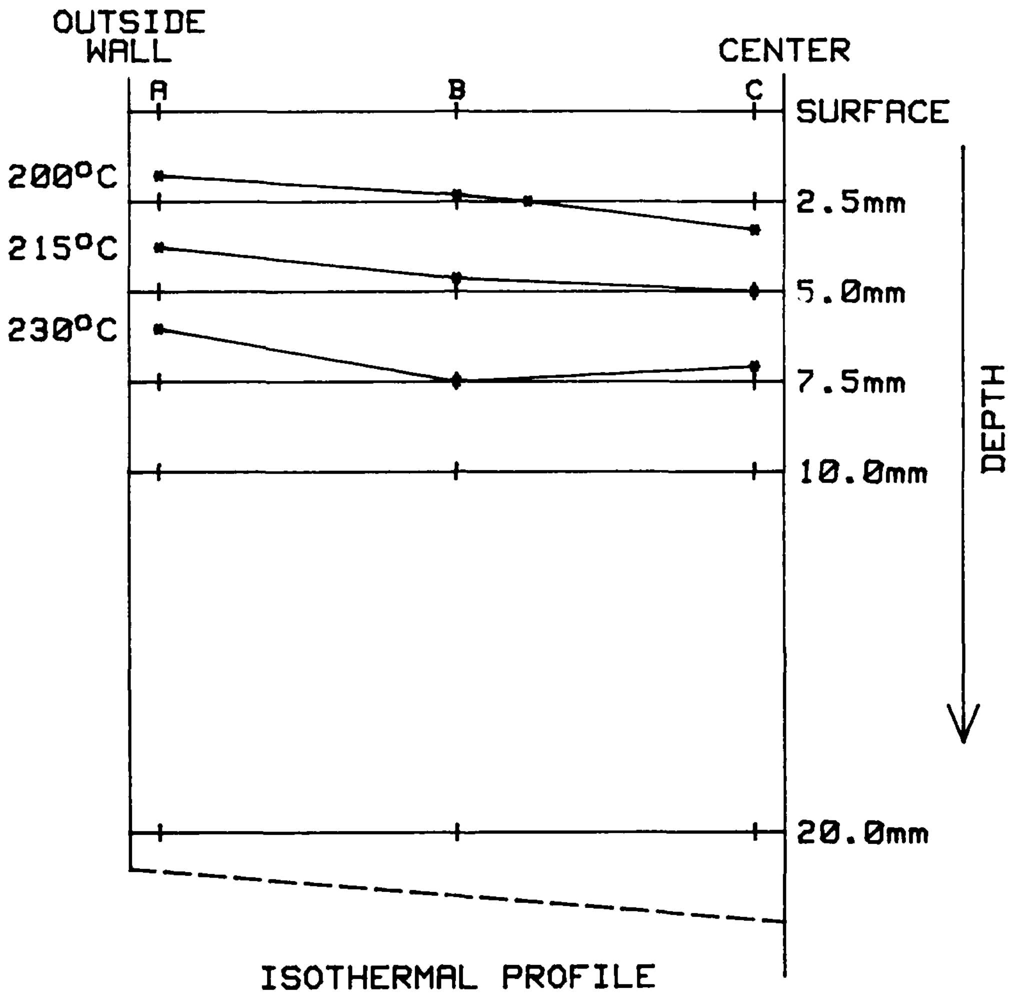
ISOTHERMAL PROFILE
TOP LAYER OF BEAD STERILIZER
NON-LAYERED SYSTEM
STAINLESS STEEL (TYPE 316L) BEADS
.125 INCH (3.2mm) DIAMETER

FIGURE 6



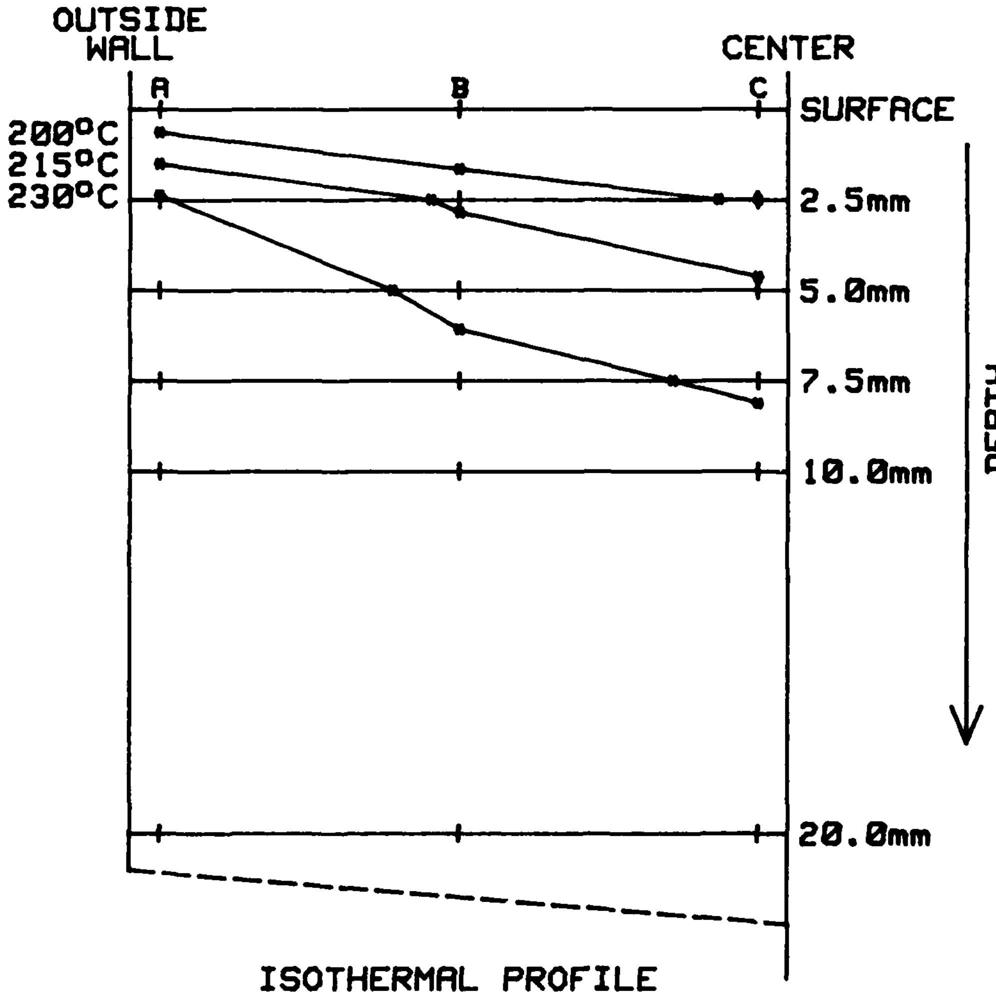
ISOTHERMAL PROFILE
TOP LAYER OF BEAD STERILIZER
TWO LAYERED SYSTEM
GLASS BEADS - TOP 2.5mm LAYER
.067 INCH (1.69mm) DIAMETER
STAINLESS STEEL (TYPE 316L) BEADS - REMAINDER
.062 INCH (1.6mm) DIAMETER

FIGURE 7



ISOTHERMAL PROFILE
TOP LAYER OF BEAD STERILIZER
NON-LAYERED SYSTEM
ALUMINUM BEADS
.125 INCH (3.2mm) DIAMETER

FIGURE 8



ISOTHERMAL PROFILE
TOP LAYER OF BEAD STERILIZER
NON-LAYERED SYSTEM
SODIUM CHLORIDE SALT
SIGMA GRADE

TABLE 1

CALCULATED SLOPES OF 200, 215, AND 230 ^{0}C ISOTHERMAL GRADIENTS.

MATERIAL & SIZE	ISOTHERMAL GRADIENT		
	200 ^{0}C	215 ^{0}C	230 ^{0}C
GLASS - 1.69 MM	-0.37	-0.42	-0.50
GLASS - 3.1 MM	-0.46	-0.54	-0.57
S.S. - 1.6 MM	-0.09	-0.17	-0.19
S.S. - 3.2 MM	-0.13	-0.12	-0.18
ALUM. - 3.2 MM	-0.11	-0.09	-0.07
COMBINATION OF GLASS ON S.S.	-0.27	-0.27	-0.36
NACL SALT	-0.12	-0.19	-0.35

NOTES:

1. FORMULA FOR THE CALCULATION OF THE SLOPES WAS $Y = MX + B$, WHERE

$$M = Y_2 - Y_1 / X_2 - X_1 .$$

2. S.S. - STAINLESS STEEL.
3. ALUM.- ALUMINUM.

TABLE 2

TIME REQUIRED FOR BUR TO REACH 218 ^{O}C.

CHAMBER POSITION	MATERIAL IN CHAMBER			
	GLASS	STAINLESS	ALUMINUM	NACL
CENTER	GREATER THAN 600 SEC	53 SEC	50 SEC	123 SEC
BETWEEN CENTER & WALL	150 SEC	39 SEC	46 SEC	63 SEC
WALL	55 SEC	25 SEC	24 SEC	35 SEC

NOTES:

1. TIME FOR THE EXPOSED END OF BUR (LAST 3 MM) TO REACH 218 ^{O}C.
2. BUR SUBMERGED IN BEADS TO A DEPTH OF 12 MM.
3. #37 BUR USED; LENGTH IS 22MM.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) THERMAL PROFILE OF METALLIC BEADS IN A BEAD STERLIZER		5. TYPE OF REPORT & PERIOD COVERED
		6. PERFORMING ORG. REPORT NUMBER NDRI-PR 86-09
7. AUTHOR(s) A. SEROWSKI and P. M. HAMILTON		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Dental Research Institute Naval Training Center, Building 1-H Great Lakes, Illinois 60088-5259		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 63706N M0095003-3028
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Medical Research and Development Command, Naval Medical Command, National Capital Region, Bethesda, MD 20814-5044		12. REPORT DATE AUGUST 1986
		13. NUMBER OF PAGES 14
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) Commander, Naval Medical Command Navy Department Washington, D. C. 20372		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

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18. SUPPLEMENTARY NOTES

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dentistry
Endodontics
Sterilization
Sterilization equipment
Medical equipment

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Previous studies have shown that the thermal profile of bead sterilization chambers using a glass bead media are not uniform, containing regions well below indicated temperature. This study tests the effects of various heat exchange media on the heat transfer/heat distribution characteristics of a bead sterilizer. The purpose is to define conditions whereby a bead sterilizer may be used as a reliable chairside bur sterilizer. Media tested consisted of glass beads .067in (standard) and .118in dia. as

controls; stainless steel balls .063in and .125in dia. and aluminum beads .125in dia. Further, the combination of .063in stainless steel with a .10in (2.5 mm) thick cover layer of .067in glass beads was tested to ascertain if the layer of glass provides a thermal insulating effect. Pyrometer readings were taken at depths of .10in, .20in, .30in, .40in, and .80in and at locations of the chamber wall, the midpoint to the axis/wall and the axis. Thermal profiles were graphed for temperature as a function of chamber depth. An "insulating effect" was defined by the thermal profile showing an increase in the heat containment within the chamber and a higher temperature differential between the surface and the media. On comparing aluminum and stainless steel beads to glass beads, a 6.5% to 7.5% temperature increase in the first .40in (10.0 mm) of chamber depth was noted. A more uniform temperature profile was observed from the central axis to the outside wall indicating an improvement in the heat distribution profile. Adding an insulating top layer of glass beads to the stainless steel and aluminum bead media resulted in a slightly more uniform temperature profile than with the glass media alone, but did not produce a significant insulating effect. Aluminum and stainless steel bead media were shown to provide a more uniform thermal profile over standard glass bead media.

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